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G3N NGE1B N277D
U1S S2400

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GB 2001166 A EP 0491619 A2 US 5180896 A
US 5134263 A US 4647746 A US 4383157 A

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UK CL (Edition M) H5H HMAX HMCR HMN
INT CL[5] F24C 7/02 7/08 , H05B 6/68 6/80

(54) Microwave oven having non-contact temperature sensor for food

(57) A microwave oven for use by the elderly consists of a generally cuboidal housing 1 with the front upper corner rounded off. The door 2 slides in tracks 25 up and over into the top of the housing 1. A shelf 9 extends in front of the housing 1, to assist in removing food from the oven. An infrared temperature sensor 100 detects the food temperature, and the magnetron 5 is switched off if overheating occurs. The temperature sensor 100 is used to measure the initial food temperature, which is used to calculate a cooking time together with inputted food type, weight and cooking mode, so that it is not necessary to input a cooking time.

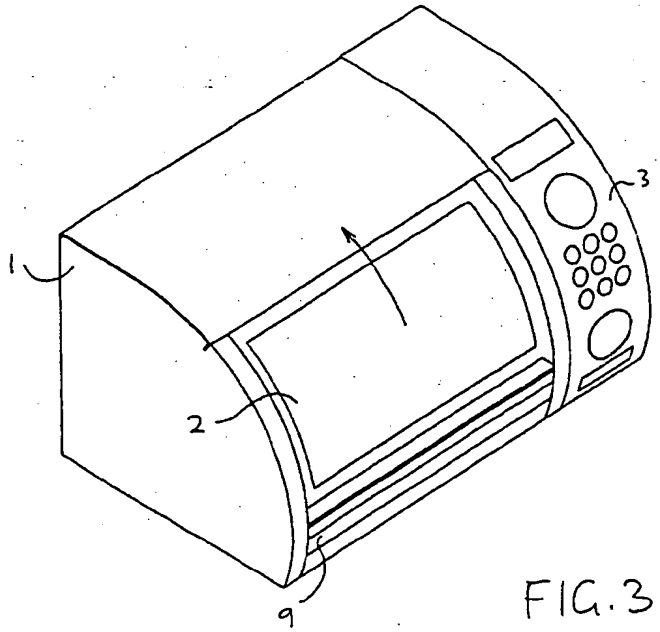

FIG.3

GB 2 280 829 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print incorporates corrections made under Section 117(1) of the Patents Act 1977.

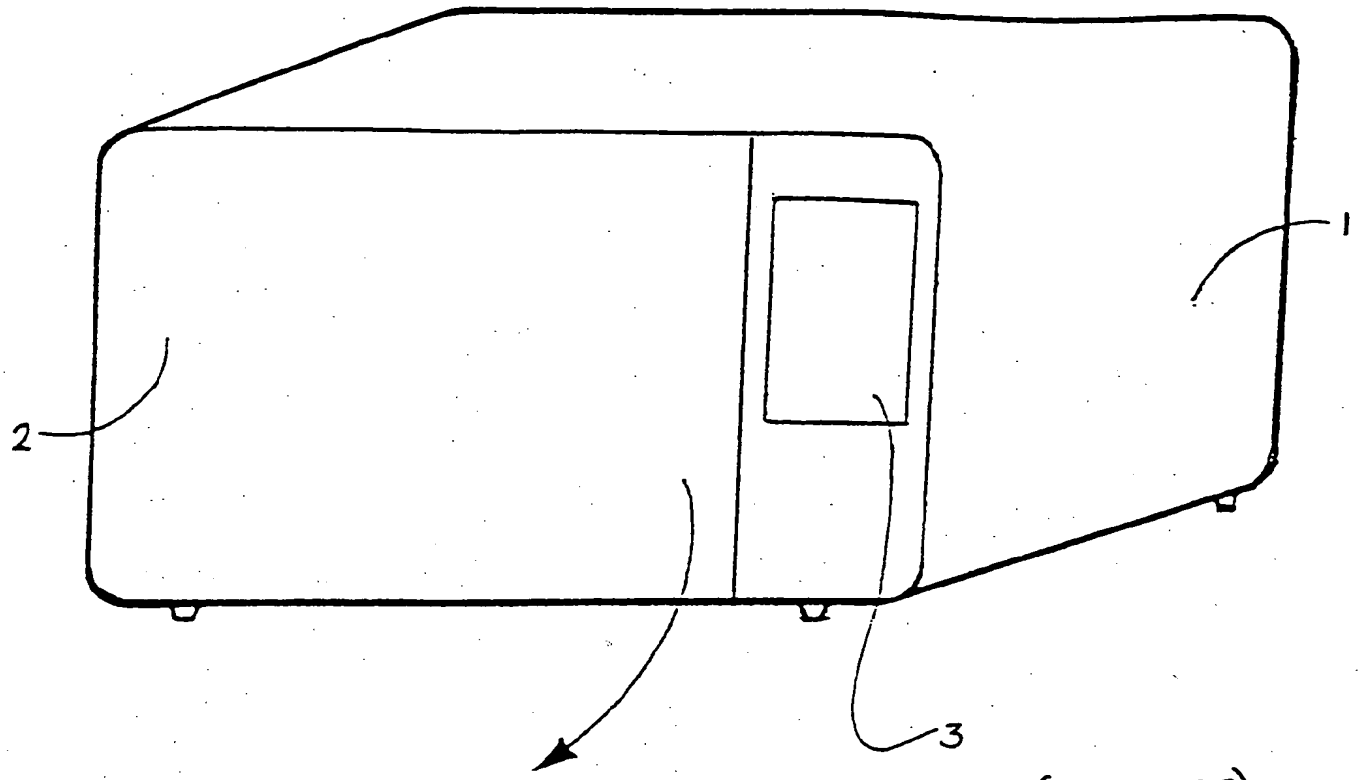

FIG. 1 (PRIOR ART)

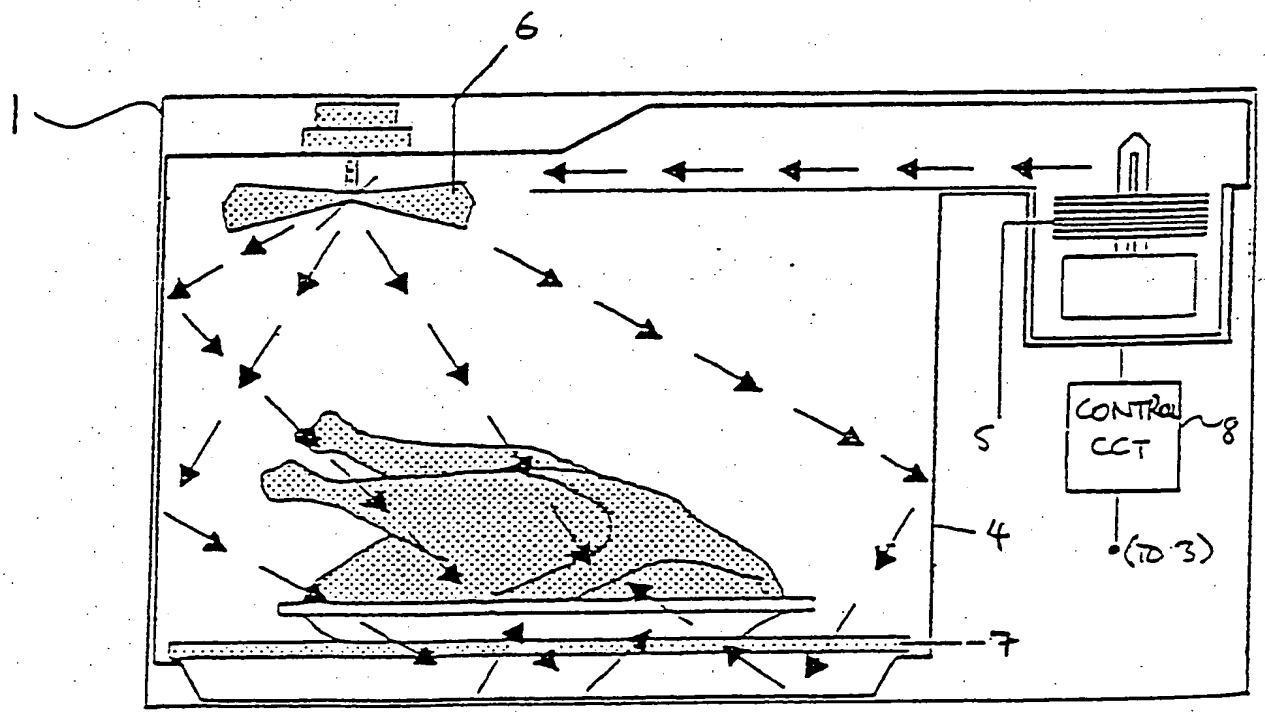

FIG. 2 (PRIOR ART)

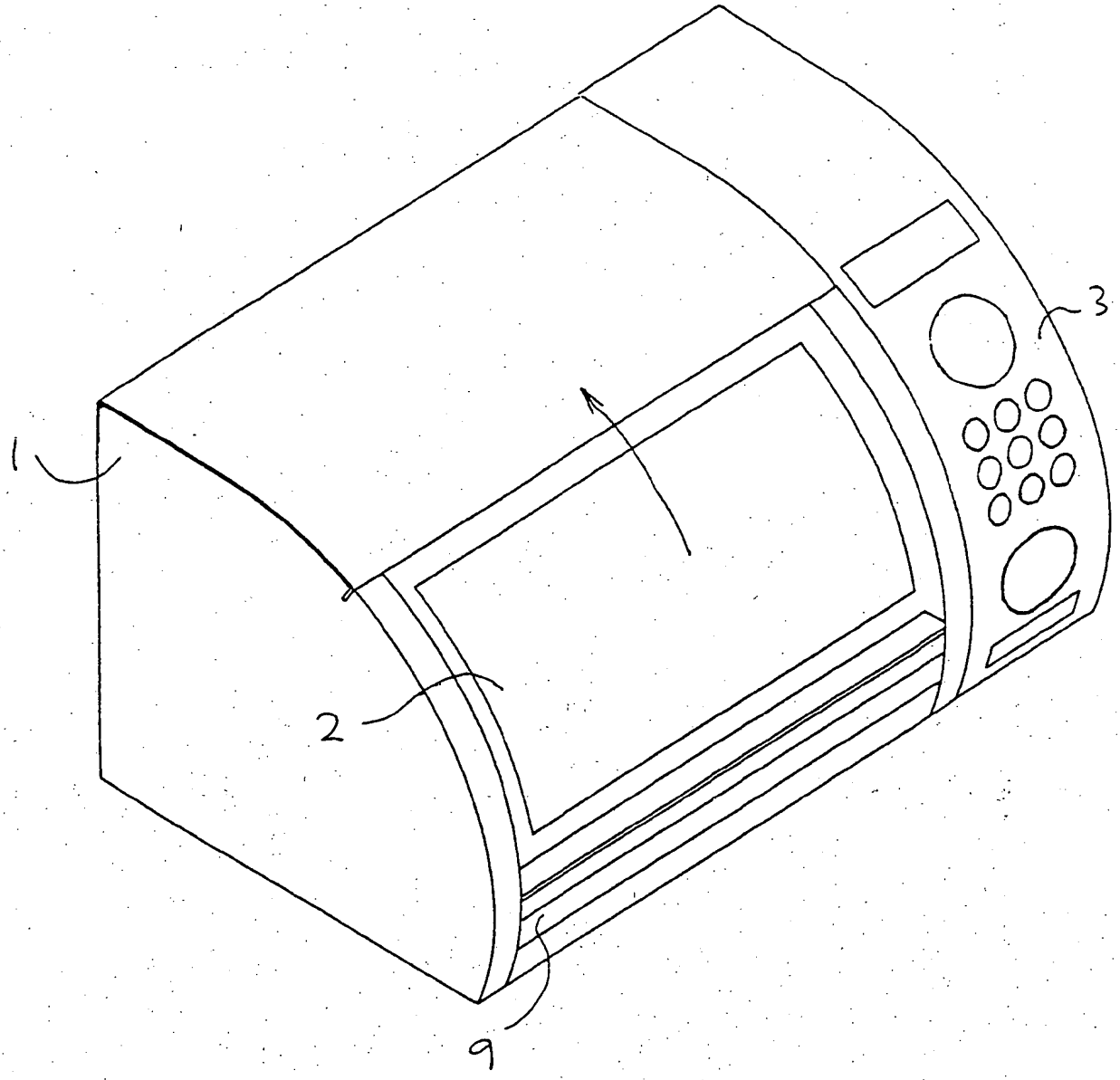

FIG. 3

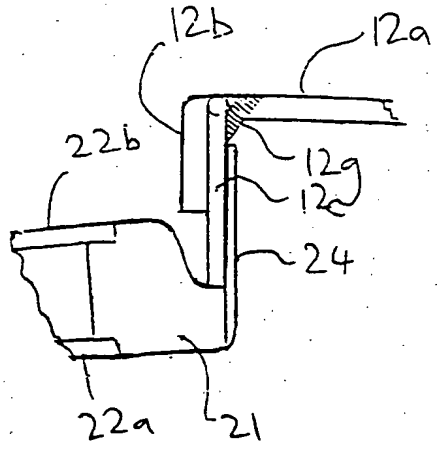

FIG. 4b

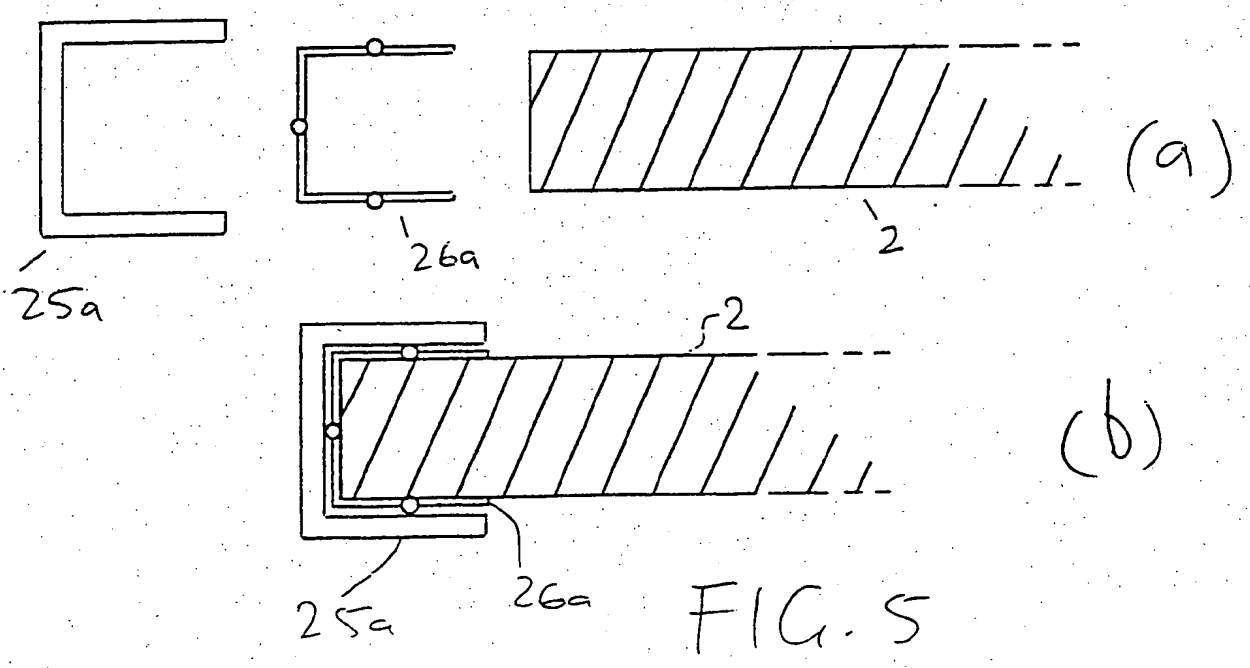

FIG. 5

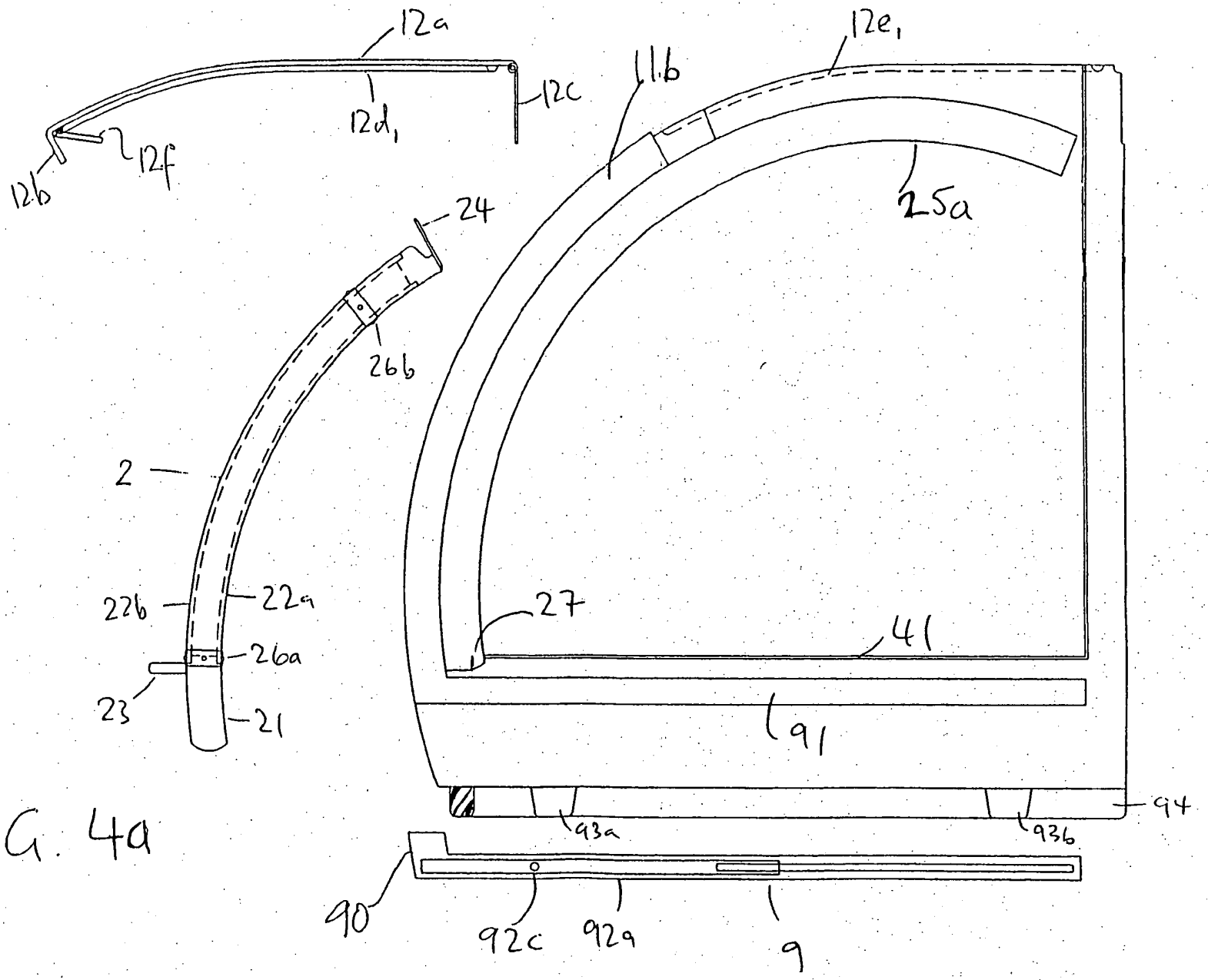
12a
12e1
11b
12c
12d1
12f
12b
24
25a
26b
2
22b
22a
27
41
26a
23
21
91
94
93a
93b
90
92c
92a
9

FIG. 4a

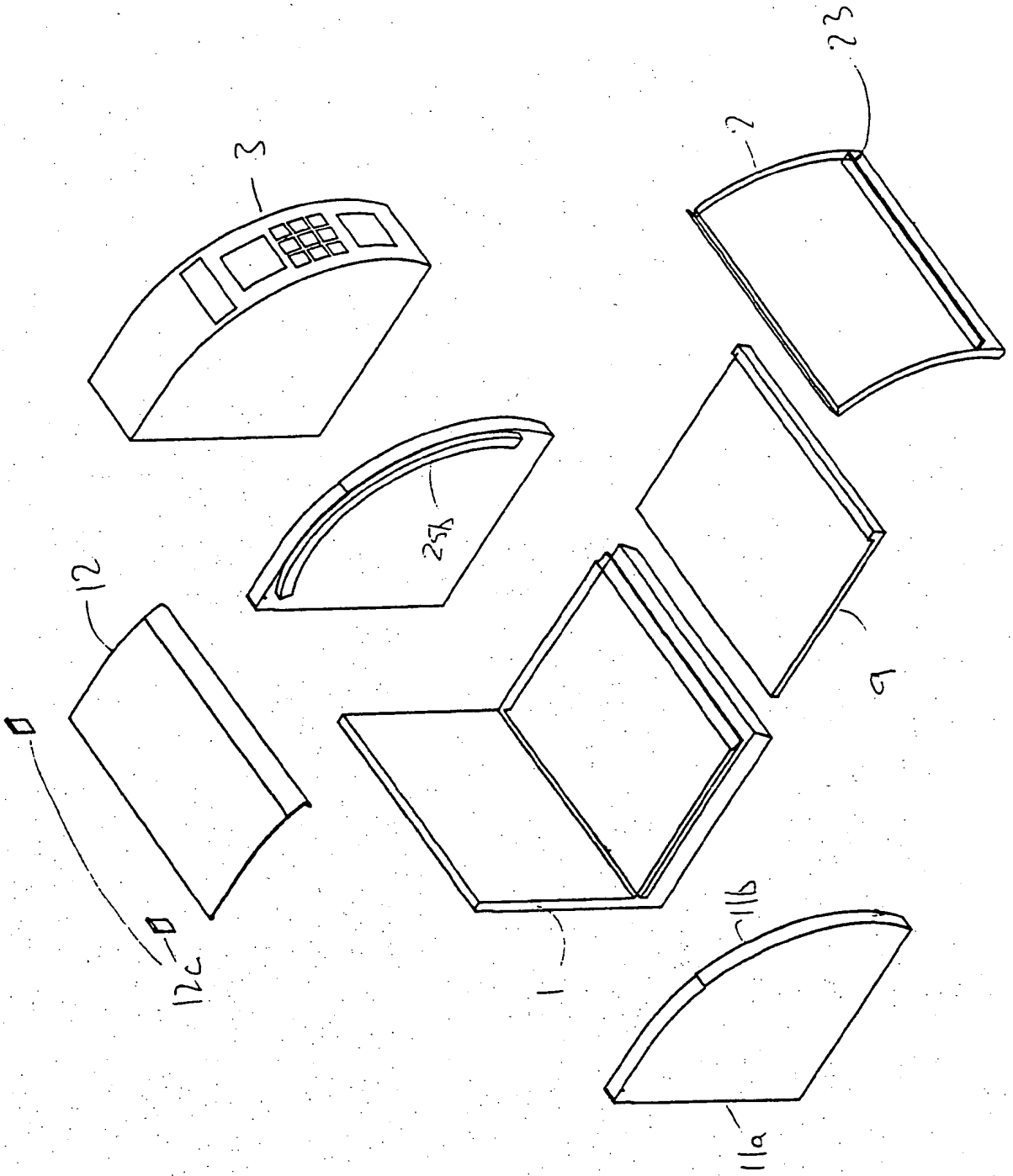

FIG. 6

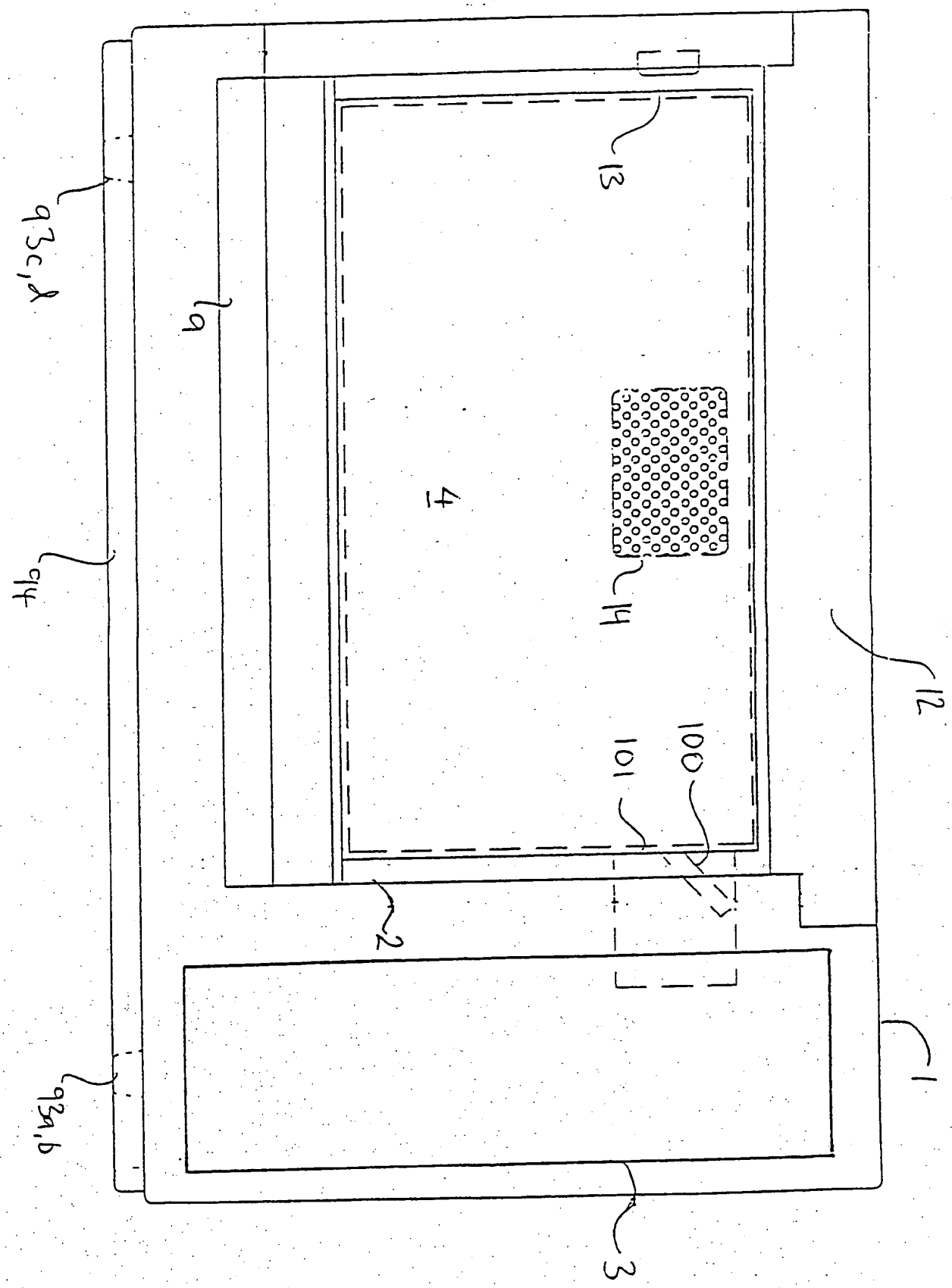

FIG. 7

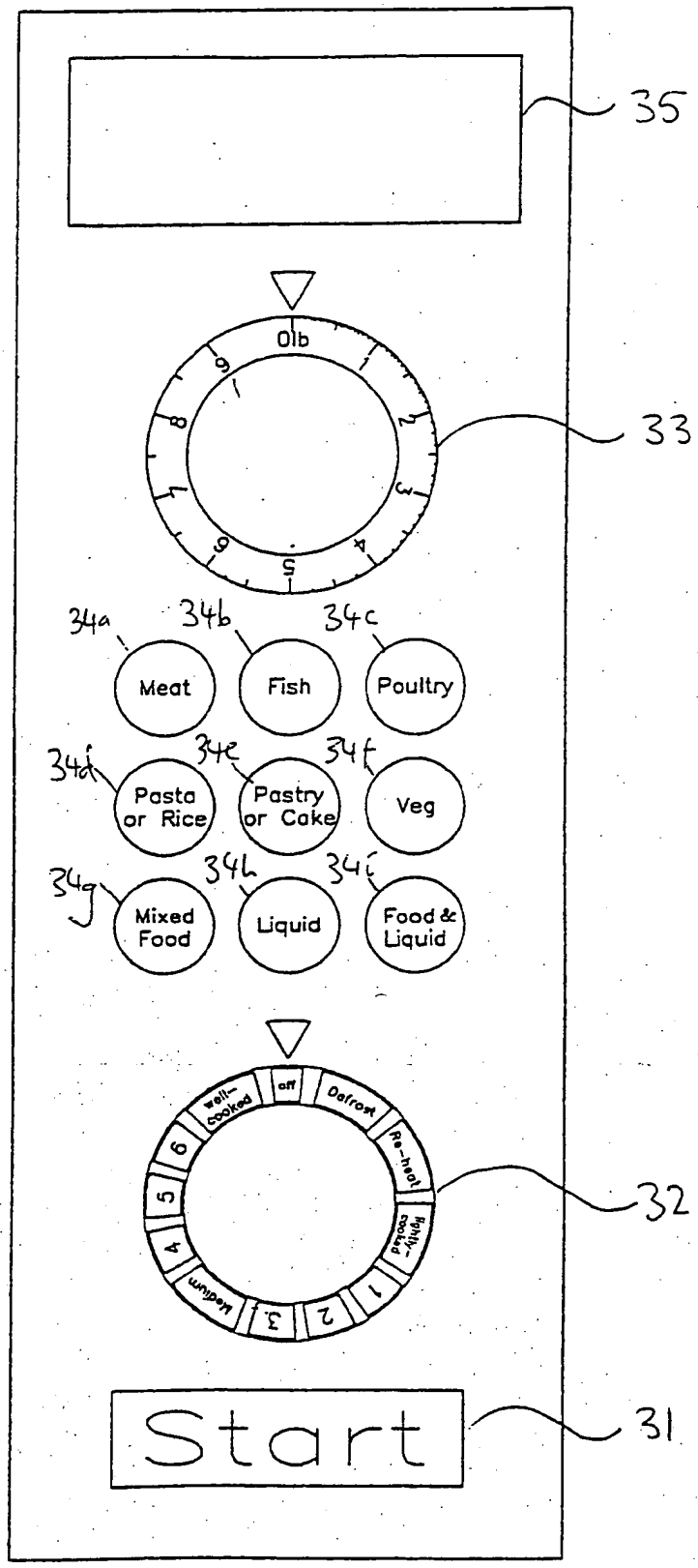
35
0lb
1
2
3
4
5
6
7
8
9
33
34a
34b
34c
Meat
Fish
Poultry
34d
34e
34f
Pasta or Rice
Pastry or Cake
Veg
34g
34h
34i
Mixed Food
Liquid
Food & Liquid
off
Defrost
Re-heat
Partly cooked
1
2
3
Medium
4
5
9
well-Cooked
32
Start
31

FIG. 8

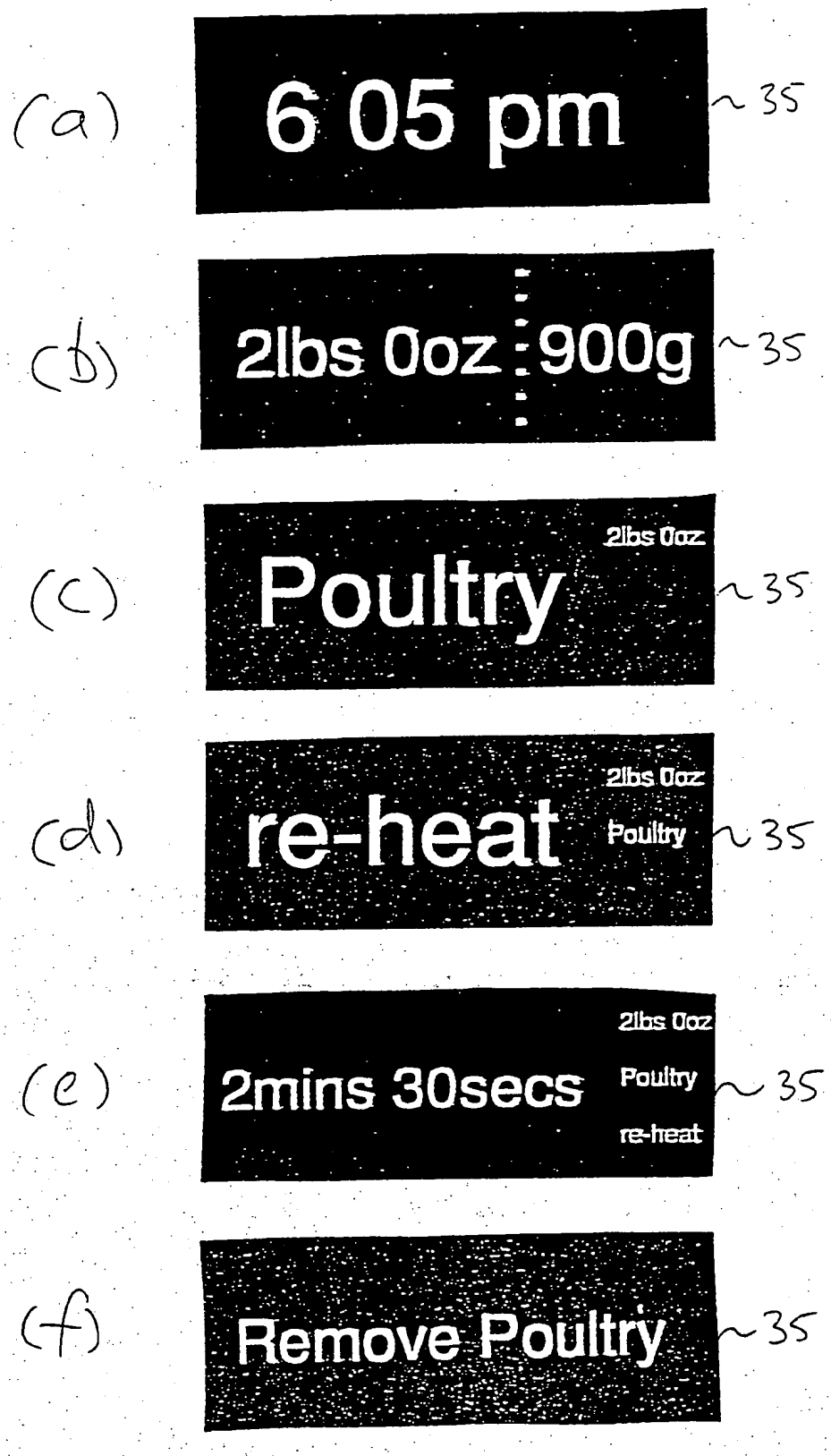
(a)
6 05 pm
~35
(b)
2lbs 0oz
900g
~35
(c)
2lbs 0oz
Poultry
~35
(d)
2lbs 0oz
re-heat
Poultry
~35
(e)
2mins 30secs
2lbs 0oz
Poultry
re-heat
~35
(f)
Remove Poultry
~35

FIG. 9

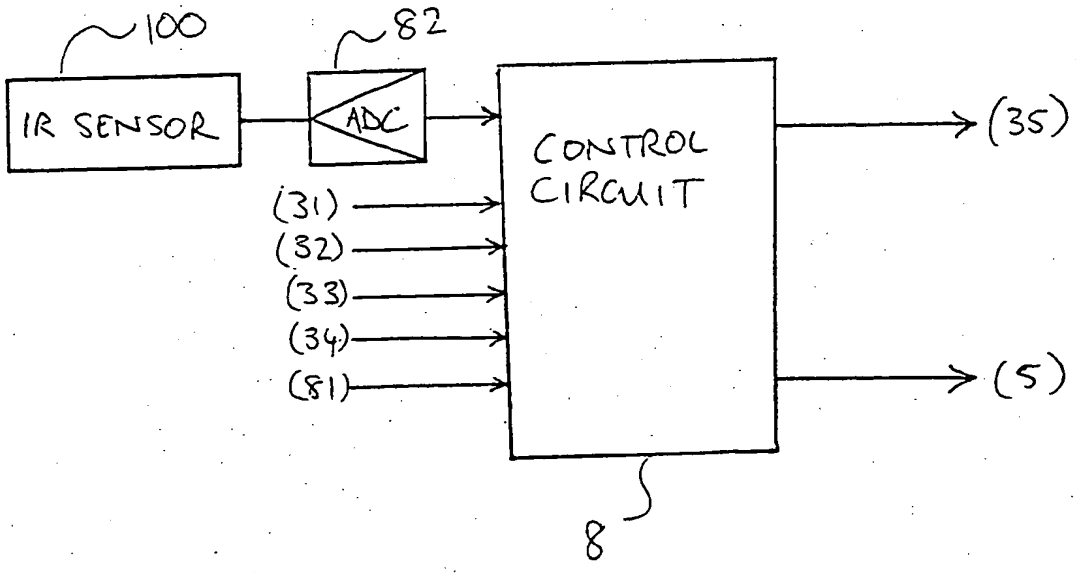
100
82
IR SENSOR
ADC
CONTROL CIRCUIT
(35)
(31)
(32)
(33)
(34)
(81)
(5)
8

FIG. 10

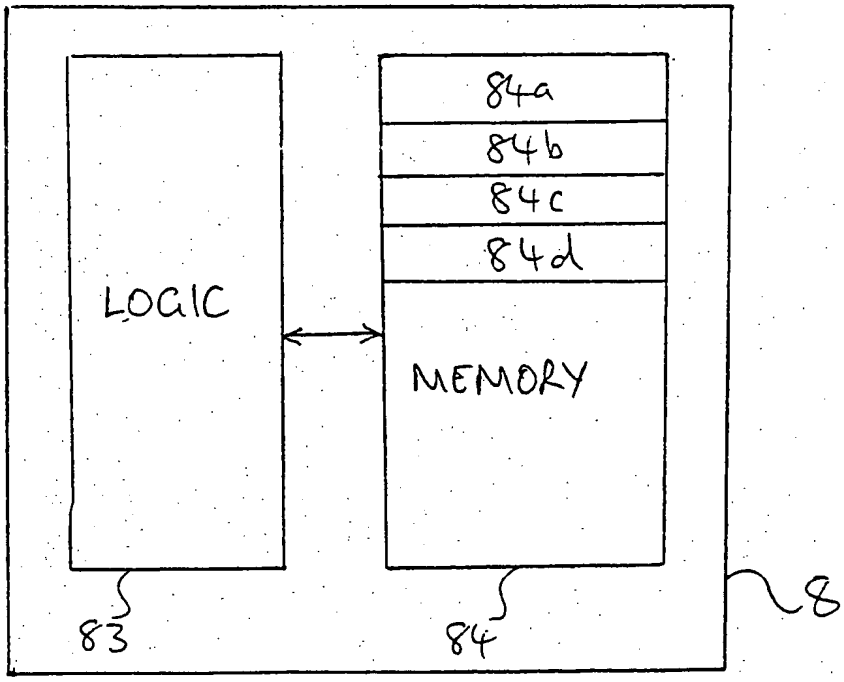
84a
84b
84c
84d
LOGIC
MEMORY
83
84
8

FIG. 11

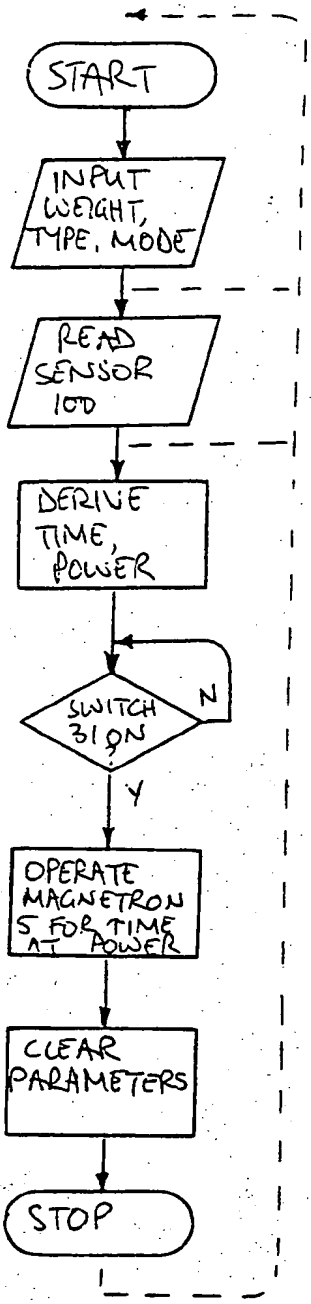
START
INPUT WEIGHT, TYPE, MODE
READ SENSOR 100
DERIVE TIME, POWER
SWITCH 31 ON ?
N
Y
OPERATE MAGNETRON 5 FOR TIME AT POWER
CLEAR PARAMETERS
STOP

FIG.12

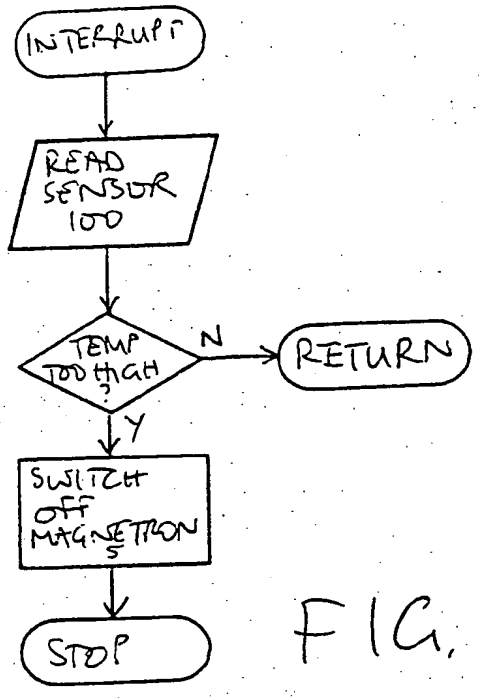
INTERRUPT
READ SENSOR 100
TEMP TOO HIGH ?
N
RETURN
Y
SWITCH OFF MAGNETRON 5
STOP

FIG. 13

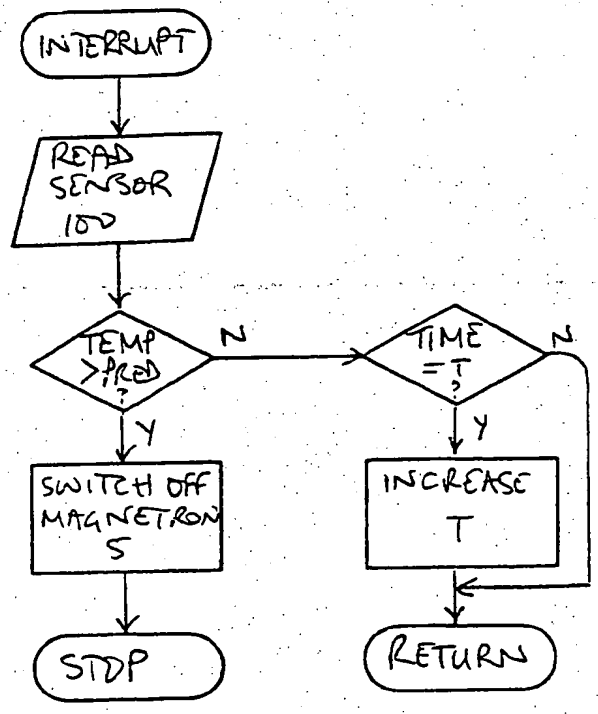
INTERRUPT
READ SENSOR 100
TEMP > PRED ?
N
TIME = T ?
N
Y
Y
SWITCH OFF MAGNETRON 5
INCREASE T
STOP
RETURN

FIG. 14

COOKING APPARATUS

This invention relates to cooking apparatus and particularly, but not exclusively, to a microwave oven.

Microwave ovens have been widely used in recent years. Some microwave ovens are constructed to be built into a vertical unit within a fitted kitchen, whilst others are constructed to be free-standing units, to be situated on a kitchen work surface.

Free-standing units are generally similar in construction to fitted units, and comprise a cuboid metal housing, with a door, closing the front of the housing, hinged about a vertical axis at one edge of the housing, to rotate open in a horizontal plane. A control panel on the front of the housing has a digital LED display and is operated by a push button array. A user enters data indicating a microwave power level and cooking time, which he must look up in a book, and the oven cooks food in the cavity for that time at that power level.

Some types of microwave oven have particular cooking modes (e.g. "defrost", which is herein considered to be a type of cooking) which, when selected, allow the user to input a food type and weight, and then select a microwave power level and

cooking time. Such arrangements are, however, notoriously inaccurate.

Some types of microwave oven have a thermocouple probe attachment, which may be inserted into a liquid or food to be heated within the microwave oven. A user enters a desired final temperature, and the liquid is heated until the thermocouple reading indicates that the final temperature has been reached, at which time the heating ceases.

Most microwave ovens have a safety circuit for switching off the microwave source (magnetron) in response to thermal sensor adjacent the magnetron itself (i.e. not in the food-receiving cavity within the oven), so as to reduce the risk of a fire if the microwave oven is set to an overlong cooking time.

Although microwave ovens have found favour with the population in general, they have failed to do so with the elderly, although elderly people would obviously benefit from the benefits of rapid and simple cooking of small quantities of foods which the microwave oven can provide.

An object of the present invention is therefore to provide cooking apparatus (for example a microwave oven) which is particularly suitable for, and attractive to, the elderly.

An alternative object of the present invention is

to provide an improved microwave (or the like) oven.

In a first aspect, the invention provides cooking apparatus comprising a housing and a door arranged to cover an opening in the housing through which food may be passed, the opening and the door being so arranged that food may be inserted forwardly and downwardly through the opening into the housing. To achieve this, the opening and the door are slanted backwards and upwards; in other words, the uppermost portion of the opening and door lie rearward of lower portions of the door and opening, and preferably overlie the food receiving surface within the oven. For example, the housing may be generally cuboidal, but with the opening extending across the area where the upper front horizontal edge would otherwise lie, so that food can be inserted or withdrawn along a diagonal into the housing.

This arrangement has the advantage that it is not necessary, when the microwave oven is provided on a work surface of conventional height, to crouch in order to insert or withdraw food from the oven. In general, it is found to provide for easier insertion and removal of food, which is particularly advantageous for people with reduced manual dexterity, and assists in avoiding messy or dangerous food spillage during insertion or removal of food from the

microwave oven.

In another aspect, the invention provides a microwave oven comprising a housing and a door closing an opening in the housing, in which the door is arranged to move or pivot in a generally vertical direction (preferably upwardly). This has the advantage that the space required to the side of the microwave oven is substantially reduced.

In a particularly preferred embodiment, the door is arranged to move upwardly rather than pivoting outwardly; this embodiment enables use to be made of the work surface in front of the microwave oven, which would otherwise need to be kept clear, to enable the door to swing open. This embodiment could also be used in cooking apparatus other than microwave ovens.

In another aspect of the invention, cooking apparatus comprises a housing with an opening, and a door closing the opening, the door having a convex curvature and being movable along a curved path from a closing position closing the opening to an opened position. Preferably, in the opened position, the door lies within the housing. By using a curved, convex door, which moves along a curved path, the volume occupied by the housing and door when the door is open can be kept relatively compact.

In a microwave oven, the door needs to be

microwave-proof, to maintain the efficiency of the cavity and to avoid leakage of potentially harmful microwaves. On the other hand, it is desirable that the door should be transparent so as to enable the condition of the food in the microwave to be monitored, so to avoid potentially dangerous overcooking. Accordingly, the doors provided in microwave ovens usually comprise two layers of glass material with a perforated metal grill or mesh in-between, which acts to block microwaves. However, it also greatly reduces the amount of light passing through the door, making visibility difficult. Further, because of the fine pitch of the mesh, visibility is only possible over a limited range of angles substantially normal to the door.

The above described door mechanism overcomes this problem to some extent, since the door is, when closing the opening in the cavity, inclined between the horizontal and vertical axes and thus light from above can penetrate into the cavity, and the normal viewing angle to the door can be achieved whilst standing rather than necessitating crouching to bring the eye level with the door. However, in a particularly preferred embodiment of the invention, visibility is enhanced by employing, as the door material, a transparent, microwave-blocking glass.

One such glass is TEMPAX (TM). This substantially enhances the visibility of the interior of the cooking apparatus. This embodiment could also be used with conventional microwave ovens.

In another aspect, the invention provides a microwave (or the like) oven comprising a housing, a door closing an opening in the front thereof, and, located beneath the door, a support member (for example a plate) which can be extended and/or removed from the housing to receive, and support, food prior to insertion into the oven or after removal therefrom. This is particularly advantageous in assisting in the removal of hot food from the oven, as it reduces the risk of spillage of hot food (particularly by those of reduced manual dexterity). Preferably, the support is arranged to lie at a height approximating that of the food supporting surface within the microwave oven, and in one embodiment, with the door open, food may be slid from the interior of the oven onto the support outside the oven without needing to be lifted by the user. The plate may, in one embodiment, be removed altogether, to act as a tray.

In a further aspect, the present invention provides a radiative cooking oven including a control unit for controlling the radiation (e.g. microwave radiation) during cooking and further comprising a

non-contact temperature sensor arranged to detect the temperature of the food therein. Preferably, the non-contact sensor is an infrared sensor, arranged to detect infrared radiation from the food. This arrangement permits the monitoring of the temperature of solid foodstuffs, into which a thermocouple could not be inserted. Further, it is more hygienic than the use of a thermocouple, and more appealing to users who may feel a prejudice against the insertion of foreign bodies into foodstuffs. A non-contact sensor of this type is particularly suitable for use in the aspect of the invention described below.

A further aspect of the invention provides a radiation cooking oven (e.g. a microwave oven) comprising a control circuit for controlling the radiation level and cooking time and a temperature sensor arranged to detect the initial temperature of food placed in the oven, the control circuit being responsive to the temperature sensor to control the level or time of cooking independence upon the initial temperature. This has the advantage of making control of the cooking very much more precise. Preferably, the oven further comprises input means arranged to input food type and weight data and cooking mode data, and the control circuit is arranged to select the radiation power and cooking time in dependence upon

the data and the initial temperature, whereby the user is not required to enter a cooking time. This arrangement is particularly advantageous for the elderly, who are skilled at determining food type and weight and are well aware of type of cooking required, but who are unfamiliar with the timings required by microwave cookery.

In another aspect, the invention provides a microwave oven, particularly for use by the elderly, which comprises a control circuit for controlling the microwave power and cooking time and input means for inputting food type, food weight and one of a plurality of desired cooking modes, whereby entry of a cooking time is unnecessary. This is advantageous for the reasons above. In one embodiment, entry of a cooking time by the user is impossible; this avoids overcooking or undercooking based on a misunderstanding of the timer operation.

In either of the last two aspects, preferably, the food temperature is sensed throughout the cooking time. This enables a number of advantageous operations of the control circuit. Firstly, cooking may be terminated if the food temperature reaches a dangerously high level. Secondly, by comparing the food temperature with a predicted food temperature appropriate to the stage of cooking reached, the

cooking time and/or power may be increased or decreased to bring the food temperature closer to its desired or predicted level. Alternatively, if the temperature is below the desired level at the end of cooking, an indication to this effect maybe given to the user (for example on a display panel).

It will be understood that in many aspects, the invention is applicable not only to microwave ovens but also to ovens which operate by generation of radiation in other areas of the frequency spectrum (for example, inductive heating ovens).

The above and other aspects, embodiments and preferred features of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows the external appearance of a conventional microwave oven;

Figure 2 shows schematically the internal components of a convention microwave oven;

Figure 3 shows an isometric view of the external appearance of a microwave oven according to a preferred embodiment of the invention;

Figure 4a is a sectional view through the oven of Figure 3 from the left hand end thereof, with the door, lid and tray separated; and

Figure 4b is a corresponding sectional view

showing the door and lid assembled in the closed position;

Figure 5a is a vertical section through the door and track shown in Figure 4, with components separated for clarity; and

Figure 5b corresponds to Figure 5a but with the components assembled;

Figure 6 is an exploded isometric view of the embodiment of Figure 3 showing the arrangement of the door, lid and tray of Figure 4 and with other components removed for clarity;

Figure 7 is a front elevation of the embodiment of Figure 3 with some hidden details shown for clarity;

Figure 8 is a view of the control panel of the embodiment of Figure 3 projected onto a flat surface;

Figures 9a-9f are displays on a display forming part of the panel of Figure 8 during stages of cooking;

Figure 10 is a block diagram showing schematically the elements of a control circuit of the embodiment of Figure 3;

Figure 11 is a block diagram showing schematically in greater detail the control circuit of Figure 10;

Figure 12 is a flow diagram showing schematically

the general flow of operation of the control circuit of Figures 10 and 11;

Figure 13 is a flow diagram showing schematically an interrupt operation of the control circuit of Figures 10 and 11; and

Figure 14 is a flow diagram showing an interrupt operation in an alternative embodiment to that of Figure 13.

CONVENTIONAL MICROWAVE OVEN

Referring to Figure 1, a conventional microwave oven comprises a generally cuboidal housing 1 having an interior cooking space or cavity, and a door 2 mounted to close the opening in the front face of the housing 1, pivoted about a vertical axis on (for example) the left hand vertical edge of the housing 1 so that the door swings open outwardly, by tracing a horizontal arc. Also on the front of the housing 1 is a control panel 3 comprising a LED bar segment display and a number of control buttons, for setting the cooking time and power.

Referring to Figure 2, within the housing 1 the cuboidal cooking space or cavity 4 communicates with the magnetron 5 which generates microwave radiation via a waveguide. In the type of microwave oven

illustrated a "stirrer" 6 comprising a number of metal vanes mounted to be rotatable is provided in the path of microwaves from the magnetron 5 and is rotated so as to deflect microwaves in an even and dispersed fashion throughout the cavity 4. The stirrer 6 may be rotated by a drive belt from, for example, a cooling fan conventionally provided to cool the magnetron 5; alternatively, it may passively be rotated by the flow of air from such a fan, or may be driven from an independent motor.

It is known to provide a stirrer 6 having a number of irregularly shaped (i.e. differently shaped) blades, in order to more evenly distribute microwaves within the cavity 4.

It is common to provide, as a food supporting surface within the cavity 4, a rotated plate 7 which rotates food within the cavity 4 so as to reduce the occurrence of hot and cold spots in the food. However, where a stirrer 6 (and more particularly a stirrer with irregularly shaped blades) is provided, such a rotating support 7 maybe unnecessary.

A control circuit 8 is provided, which is connected to the magnetron 5 to control the level of microwave radiation thereby, and is connected to the control panel 3 to receive user input from the keypad or buttons thereon, and to control the LED display

indicating system settings.

The control circuit 8 may comprise a programmed micro-controller or microcomputer circuit (for example an 8-bit industrial micro-controller) together with read only memory (ROM) storing cooking data for relating the desired type of cooking, food type and weight to the desired cooking time.

Microwave ovens of this type are extremely well known, and the foregoing description is therefore by way of a summary only.

PREFERRED EMBODIMENT

A preferred embodiment of the invention will now be described. Since many components of the embodiment are similar or identical to those of a conventional microwave oven, they will not further be described.

Referring to Figure 3, a microwave oven comprises a housing 1. The housing 1 comprises rectangular back and floor panels (not shown in Figure 3), a pair of planar side panels having front edges exhibiting a convex curvature, and a curved front face running between the curved edges of the side panels, and comprising the control panel 3, the door 2, and panels surrounding the door 2.

As with a conventional microwave oven, the

housing 1 comprises metal walls. The door 2 comprises a transparent microwave proof glass material, as will be discussed in greater detail below.

Beneath the door 2 is located an extending shelf 9, which can be pulled out from within the housing 1 to provide a support for food.

The door 2 is opened by sliding it upwardly, following the curve of the front face of the housing 1, into the housing to expose the cavity 4 within the housing.

Internally, the arrangement of the microwave of Figure 3 is similar to that of Figure 2, the magnetron 5 and control circuit 8 being located behind the control panel 3, and the waveguide and stirrer beneath the tray 9.

Door Arrangement

Referring to Figure 4a, the door 2 comprises an outer frame of 1mm thick mild steel sheet, surrounding two 2mm thick curved sheets of glass 22a, 22b disposed in parallel relationship. Near the lower edge of the door 2 is a handle strip 23 extending outwardly and running horizontally along the door. At the upper edge of the door 2 is a protruding rim 24 extending outwardly of the door 2 and running the length of the door.

The outer sheet 22b of the door 2 comprises toughened, scratch proof glass, and the inner sheet 22a comprises microwave proof glass, for example a borosilicate glass, such as Tempax®, manufactured by Schott Glaswerke, available from P.O. Box 2480, D-6500, Mainz, Germany. With appropriate forming, it might alternatively be possible to employ DATASTOP(™) glass, available from Pilkington Glass Limited, Alexandra Works, St. Helens, England WA10 3TT.

The left hand end plate 11 of the housing comprises an outer surface 11a and an inner surface 11b (which defines the surface of the cavity 4). Within the inner surface 11b is disposed a groove 25a following a circular arc from the position of the bottom of the door 2 when in its closed position to the rear of the housing 1 and plate 11b. A similar groove 25b is provided in the other side of the cavity 4.

Referring to Figure 5, on each of the side edges of the door 2 are provided a pair of bearings 26a, 26b each comprising an injection moulded nylon cap carrying protruding bumps. The caps are 2.9mm thick, with 0.1mm tolerance. This ensures that the largest gap between the door 2 and the groove 25 at any point is less than 3mm (preferably 1mm), so that the four sets of double angles provide more than sufficient

microwave proofing. Thus the door 2 can, by manipulating the handle 23, be rolled up and into the housing 1, sliding within the tracks 25a, 25b.

The strip 24 at the rear of the door 2 carries a magnet which engages the rear of each track 25, so that when the door 2 is fully open the magnet holds it open. In fact, in this embodiment, preferably the center of gravity of the door 2 is, when the door is fully opened, rotated over the top of the circular arcs defining the grooves 25, so that the weight of the door tends to hold it at the back of the grooves 25 rather than tending to roll it forward. Accordingly, it is possible to dispense with this magnetic catch arrangement.

The lowermost surface of the door 21 engages a groove 27 in the base of the cavity 4, in which the door sits when closed. The groove 27 is lined with rubber to ensure that no damage occurs if the door is violently closed. The provision of the groove 27 prevents leakage of microwaves by providing a double angle around the door 2.

Since the weight of the door tends to keep the door closed, no separate door latch or lock (as used in conventional microwave ovens) is necessary. A microswitch contact sensor 81 is provided in the groove 27 connected to the control circuit 8, so that

when the door is not closed (and the microswitch operated), the control circuit 8 switches off the magnetron 5.

Lid 12

Referring once more to Figure 4a, and to Figure 6, the portion of the housing 1 lying behind and above the door 2 comprises a lid 12 comprising a top plate 12a having a flat upper/rear portion and a curved front portion, with an overhanging inward turned lip 12b running along the front of the lid 12. Two small mounting plates 12c on the rear edge of the lid 12 and hinged to the top plate 12a, are fastened (e.g spot welded) to the rear panel of the housing 1, so that the top plate 12a is hinged to the housing 1 along its rearward edge.

It is therefore possible to open the lid by hinging the lid 12 about the hinges at its rearward edge, so as to be able to clean the walls of the cavity 4, the door 2 and the lid more effectively. Within the front flange 12b is disposed a protruding rim 12f hinged to the upper plate 12a and urged upwardly towards the upper plate by a spring 12g as shown in Figure 4b.

In use, as the door 2 slides downwardly in the tracks 25, the rearward plate 24 of the door engages

the hinged flange 12f in the lid 12, pulling it forwardly and being retained in engagement by the spring hinging the flange 12f to the lid 12a, so as to provide a microwave-proof double angle seal.

Running fore and aft at the sides and the back of the lid 12 are spaced parallel ridges $12d_1$, $12d_2$, $12d_3$ The ridges $12d_1$ .... are received in corresponding grooves $12e_1$, ... in underlying flanges of the housing under the side and rear edges of the lid 12.

The ridges 12d, $12d_2$ carry, towards the front thereof, magnetic strips which engage corresponding strips in the grooves 12e, retaining the ridges 12d in the grooves 12e which thus provide double-angle microwave traps preventing leakage of microwaves under the lid.

A pin (not shown) is arranged to separate the magnetic strips on respective ridges 12d and grooves 12e on actuation of a button 13 (shown in Figure 7, and connected to the pin by a lever, not shown) which is located inside the oven cavity 4. Thus, the magnets hold the lid closed except when the oven is opened to actuate the button 13 (and, as discussed below, whilst the door is open, the magnetron is switched off). Accordingly, the lid cannot be opened while the oven is operating.

Shelf 9

The shelf 9, as shown in Figure 4, has an upwardly extending front lip 90 which sits beneath the handle of 23 of the door 2 and extends above the groove 27 when the tray 9 is fully within the housing 1.

A slot 91 extends, beneath the cavity 4, into the housing 1 to receive the tray 9. At either edge of the tray 9, there are provided channels 92a, 92b (not shown) which engage with protruding features at either edge of the slot 91 to enable the tray to slide in and out, and to be withdrawn from the slot 91 by releasing catches 92c, 92d. Conveniently, a mechanism of the type widely used in kitchen drawers may be employed for the sliding channels 92a, 92b and protruding features in the slot 91.

The shelf 9 does not play a part in sealing the cavity 4, and the oven can therefore be operated with the shelf 9 fully extended or removed.

In use, with the shelf 9 extended from the housing 1, hot food may be urged outwardly of the bottom, food supporting, surface 41 of the cavity 4, over the channel 27, and on to the extended plate 9, the upper surface of which lies only slightly below the food supporting surface 41. The food may then be

left on the shelf 9 to continue cooking, or to cool. In this position it is considerably more accessible than within the cavity 4, and hence the risk of spillage is reduced. Subsequently, it may be removed to act as a tray for carrying the food. Similarly, the shelf 9 may be employed to assist in placing food into the cavity 4. The shelf 9 may be of a heat-insulating material (e.g. a plastic material).

Support and Sealing Structure

Supporting the weight of the oven are four support legs 93a - 93d positioned to carry the weight of the magnetron 5 and mains transformer.

Running around the front and sides of the oven surrounding the legs 93a - 93d, is a silicone rubber sealing ring attached to the lower surface of the housing 1, which acts as a dirt exclusion seal. The sealing ring 94, when undeformed, extends further from the housing 1 than the legs 93a -93d. However, it is made of sufficiently elastically deformable silicone rubber that, upon being placed upon a worktop, the weight of the oven compresses the seal until the legs 93a - 93d engage the work surface and support the weight of the oven. The silicone rubber seal therefore seals against the work surface, and prevents

spillages extending under the oven in use.

CONTROL SYSTEM

The control system comprises three parts; a temperature sensor 100, the control circuit 8, and the control/display panel 3.

Temperature Sensor 100

Referring to Figure 7, a temperature sensor 100 comprising in this embodiment, an uncooled pyroelectric sensor sensing infrared radiation emissions, is mounted outside the cavity 4, aligned with the central region of the cavity 4 where food will, in use, be positioned. The portion of the cavity wall behind which the sensor 100 is positioned comprises a microwave-proof borosilicate glass window 101 which protects the sensor from food spillage, whilst passing infrared radiation.

The output of the sensor 100 therefore represents the level of infrared radiation emitted by the food within the cavity 100, which in turn is directly related to its surface temperature. Suitable pyroelectric sensors are well known in, for example, military or fire control applications.

Control Panel 3

Referring to Figure 8, the control panel 3 comprises a start button 31, a pair of selector knobs or dials 32, 33 (the first, 32, being for selecting a cooking mode, and the second, 33, being for selecting a food weight), an array of 9 food type buttons 34a - 34i for selecting, respectively, one of meat, fish, poultry, pasta or rice, pastry or cake, vegetables, mixed foods, liquid, or food/liquid combinations; and an LED display panel 35. Each of the buttons and knobs 31 - 34 are connected as inputs to the control circuit 8 and the display 35 is driven by the output of the control circuit 8.

The weight input knob 33 may comprise a continuously variable potentiometer, connected through an analog to digital converter (not shown) to the control circuit 8.

The weight input knob 33 is rotated by the user to the desired weight setting (calibrated on the knob). To operate the weight knob, it may, for example, be depressed by the user to cause it to pop out. On detecting depression of the knob, the control circuit 8 reads the knob position and displays the corresponding weight on the display screen 35 in digital form, as illustrated in Figure 9b (as shown in

Figure 9a, when the oven is not in use, the display 35 may indicate the time).

Once the desired weight is set, the user selects the desired food type by depressing one of the buttons 34a - 34i. Upon detecting the selection, the control circuit 8 displays a legend corresponding to the selected type as shown in Figure 9c. Finally, the user manipulates the cooking mode dial 33 to the desired level of cooking (e.g. defrost, reheat, or a range of levels of cooking from lightly to well cooked). The processor 8 displays the selected cooking mode as indicated in Figure 9d. After food weight, food type and cooking mode have been entered, the processor enables the start button 31 (e.g. by releasing a solenoid to allow the button to pop out), so that a user may start the cooking process. Alternatively, the user may reselect one or more of the three parameters he has already inputted if an incorrect choice has been made. The processor calculates the desired cooking time as discussed below, and displays the cooking time, together with the three selected parameters, as shown in Figure 9e. During cooking, the processor maintains the display of Figure 9e but progressively reduces the remaining cooking time displayed. When the cooking time is elapsed, the processor displays a message indicating

that cooking is over as shown in Figure 9f.

After the cooking time is completed, the processor 8 resets the previously inputted weight, food type and cooking mode parameters, so that all three must then be re-inputted by a user; this reduces the risk of accidental wrong entry.

Control Circuit 8

The control circuit 8 selects the power level applied by the magnetron 5, and controls the length of time for which the magnetron is switched on. Accordingly, it calculates a required time from the sensed temperature and the inputted food type, food weight and cooking time. When the start button 31 is pressed, it switches the magnetron on at the desired power level for the time thus calculated and then switches the magnetron off. To prevent accidents, it also operates a number of safety routines to either prevent the magnetron from being switched off or to switch off the magnetron, under certain circumstances.

Referring to Figure 10, the control circuit 8 is connected to receive inputs from the controls 31-34 on the panel 3 and to receive, via an analog to digital converter 82, the output of the temperature sensor 100. Finally, it is connected to the door responsive

microswitch 81 discussed above. The microswitch 81 may be connected to an interrupt line of the microprocessor forming the control circuit 8 which, whenever the microswitch is open, switches off the magnetron 5.

Referring to Figure 11, in greater detail the control circuit 8 comprises a logic circuit 83 (e.g. a microprocessor) and a memory 84 storing operating data. The memory 84 includes four look-up tables 84a - 84d.

Figure 12 shows the general flow of operation of the control circuit 8 in inputting food weight, type and cooking mode and cooking the food.

In greater detail, the process of calculating the cooking time may simply be performed by using the input food type, weight and cooking mode readings, and the food starting temperature sensed by the sensor 100, as address inputs to corresponding look-up tables 84a - 84d (containing previously empirically derived sealing data), and multiplying the resulting outputs together to form the cooking time. The cooking power is derived from the cooking mode input; it will normally be full power except, for example, where defrost mode is selected. Alternatively, the processor 8 may be arranged to calculate the cooking time from these four factors, using a predetermined

algorithm for relating the food weight and starting temperature (which are relatively well characterised by mathematical expressions) and predetermined constant scaling factors for the selected food type and cooking mode.

The contents of the look-up tables 84a-84d or the predetermined weighting factors and constants used in such an algorithm are readily determined by the skilled person by repetitive experiments on different food types.

Referring to Figure 13, at frequent intervals during the cooking process, the processor 8 executes an interrupt routine to read the output of the temperature sensor 100. If the output of the sensor 100 indicates that the food surface temperature is above a predetermined level, the control circuit 8 switches off the magnetron 5. It is found that in general there is a gap of around 100°C between the lowest temperature at which the least dense food substance will combust and the highest temperature at which the most dense food substance cooks. Accordingly, the control circuit 8 responds to a food temperature lying in this gap (for example, above a threshold of 275°C) to switch off the magnetron before combustion occurs.

In a further embodiment, the control circuit 8 is

arranged to display the sensed temperature, after each reading, on the display 35, to inform the user of the food temperature during cooking.

In a yet further embodiment, the control circuit 8 is arranged to calculate, together with the cooking time, one or more food temperatures relating to predetermined times (for example, the food temperature at the end of the cooking time and possibly one or more points during the cooking time), and is arranged to compare the temperature read from the sensor 100 with the corresponding predicted food temperature at each such time. Figure 14 corresponds to Figure 13, and illustrates the process when a single predicted food temperature, corresponding to the end of the cooking time period, is employed.

If, during the cooking period, the food temperature exceeds the predicted temperature, then the magnetron 5 is switched off and the cooking is halted. This prevents overcooking due, for example, to incorrect weight entry. If, on the other hand, the food temperature is below the predicted temperature, and the time is at the end of the cooking interval, so that the food is undercooked relative to the predicted temperature, then the cooking time interval T is increased and cooking continues, until the point where the predicted cooking temperature is reached. In

further embodiments, a plurality of predicted temperatures corresponding to different stages during the cooking time are calculated, and the temperature at each stage is tested against the predicted temperature, and the cooking time is continually reduced or increased to keep the measured food temperature in correspondence with the predicted temperature.

Preferably, immediately after reading the start button 31 but before actuating the magnetron 5, the control circuit 8 is arranged to read the output of the sensor 100. If the sensor output falls below a predetermined level, it is deduced that no food material is present within the cavity 4, and the control circuit 8 disables the magnetron 5. Thus, the temperature sensor 100 also acts as a detector of the presence of food and prevents activation of the oven with no food present (which might otherwise lead to the melting of any receptacles therein). It also provides some measure of fail safe operation, since if the sensor 100 is inoperative (and hence and unable to detect overheating) the oven will not operate. In the event of detection of absence of food, the control circuit may display an "Oven Empty" message on the screen 35.

Further Features

Preferably, in this embodiment, an interior bulb is provided (not shown), of conventional design for illuminating the cavity 4 during cooking. Preferably, a vent 14 of conventional design is provided to vent the cavity 4. Preferably, a stirrer is provided, and preferably the stirrer has irregularly shaped vanes so that microwaves are evenly distributed throughout the cavity 4 and no rotary turntable is necessary. The stirrer arrangement may be driven, as in the prior art, from a cool air fan (not shown) for cooling the magnetron 5.

Other Embodiments and Modifications

In the above described embodiments, a user inputs the food weight. In an alternative embodiment, a pressure transducer is provided on the food receiving surface of the cavity 4 to directly sense the weight of food placed thereon, and provide a corresponding input to the control circuit 8.

Although in the above described embodiments the temperature sensor 100 is an uncooled pyroelectric sensor, it may be possible to achieve greater accuracy by providing a cooling system for the sensor.

Alternatively, rather than using a pyroelectric sensor, another type of infrared sensor, such as a phototransistor with a suitable optical passband filter, could be employed.

Although in the above described embodiments a predetermined cooking time is calculated, it would equally be possible merely to calculate a cooking temperature, and to employ the sensor 100 to maintain cooking until the predetermined temperature was reached.

Although in the above described embodiments the control circuit 8 responds to the sensor 100 to vary the cooking time in dependence upon the sensed temperature, it will equally be apparent that the control circuit could vary the cooking power. For example, the control circuit may be arranged to calculate a cooking time at an intermediate power level, and to increase or decrease the power level in dependence upon whether the food temperature sensed by the sensor 100 is greater than or less than the predetermined temperature calculated to correspond to predetermined stages of cooking.

As an alternative to the knobs and buttons 32 - 34, it would be possible to provide a bar code scanner for scanning bar coded packaging of foodstuffs for weight and type.

It may be desirable to employ auditory outputs (e.g. tones) to indicate stages of cooking, to assist the visually impaired user.

It would be possible to combine the above described embodiments with any of the features found on conventional microwaves, such as additional grills, convection cookers and so on.

The oven may include a radio receiver, arranged to receive a time-setting message and the control circuit 8 may be arranged to set the time displayed on the display 35 (as shown in Figure 9a) in accordance therewith on, for example, a daily basis.

The control circuit 8 may be arranged further to monitor the condition of the apparatus, and to generate a warning message ("call engineer") on the display 35 in the event of a failure of any component.

It will be understood from the foregoing that the above described mechanical aspects of the invention each contribute to ease of use of the oven as compared to a conventional microwave oven, and therefore increase the suitability of the product for the elderly. The use of a remote temperature sensor enables the oven to be protected both against overheating of the food (which can lead to fire) and cooking without food in the oven (which can lead to melting of components and the risk of fire) and

therefore provides increased safety, which is both of benefit to the elderly and a reassuring factor encouraging their use of microwave technology.

Finally, the sensing of the initial food temperature enables the more precise calculation of the required cooking time, and thus leads to more accurate cooking, as well as enabling the input of cooking time by the user (who may be unfamiliar with the concept of microwave cooking times). These benefits are increased if the temperature is monitored during cooking.

Protection is sought for each and every novel feature of the above described embodiments, together with all obvious alternatives, variance or modifications thereof, whether or not encompassed within the scope of the accompanying claims.

CLAIMS:

1. A radiation cooking apparatus which comprises a non-contacting temperature sensor arranged to remotely sense the temperature of food located to be cooked therein.

2. Apparatus according to claim 1 in which the temperature sensor is responsive to infrared radiation.

3. Apparatus according to claim 1 or claim 2 further comprising control means arranged to control the cooking in dependence upon the sensor output.

4. Apparatus according to claim 3 in which the control means is arranged to monitor the initial food temperature and to control the cooking in dependence thereon.

5. Apparatus according to claim 3 or claim 4 in which the control means is arranged to monitor the food temperature during cooking.

6. Apparatus according to claim 5 in which the control means is arranged to halt the cooking if the

food temperature exceeds a predetermined level.

7. Apparatus according to claim 5 or claim 6 in which the control means is arranged to vary the cooking profile in dependence upon the relationship between the sensed food temperature and a predetermined temperature.

8. Apparatus according to any of claims 3 to 7 in which the control means is arranged to control the cooking time in dependence upon the sensor output.

9. Apparatus according to any preceding claim in which the sensor is employed also to sense the presence or absence of food, and to prevent cooking in the absence of food.

10. A cooking apparatus comprising means for sensing initial food temperature, and means for calculating the subsequent cooking cycle based upon the sensed initial temperature.

11. A microwave oven with a sliding door.

12. Cooking apparatus comprising a housing and a door arranged to cover an opening in the housing

through which food may be passed, the opening and the door being so arranged that food may be inserted forwardly and downwardly through the opening into the housing when the door is opened.

13. Apparatus according to claim 12 comprising a microwave oven.

14. Apparatus according to claim 12 or claim 13 in which an upper portion of the door is disposed inwardly of a lower portion of the door.

15. Apparatus according to any of claims 11 to 14 in which the door is curved convexly.

16. Apparatus according to any of claims 11 to 15 in which the housing approximates a cuboid with the front upper edge thereof removed, the door lying within where said front upper edge would have been.

17. Cooking apparatus which comprises a door of convexly curved cross section movable along a curved path between a closed position and an open position.

18. Microwave oven apparatus comprising a housing and a door closing an opening in the housing,

in which the door is arranged to move or pivot in a generally vertical direction.

19. Oven apparatus according to claim 18 in which the door is arranged to move from a closed position, upwardly into an open position.

20. Apparatus according to any of claims 11 to 19 in which the door comprises a transparent microwave blocking material.

21. A microwave oven comprising a housing, a door closing an opening in the front thereof, and, located beneath the opening, a support member which can be extended and/or removed from the housing to receive and support food inserted into or removed from the oven.

22. An oven according to claim 21 in which the support member comprises a plate receivable into and extendable from said housing.

23. A free standing microwave oven unit carrying, on the base thereof, a sealing strip of flexible, compressible material arranged to seal against the portion of a flat worksurface which is

located, in use, beneath the unit.

24. A microwave oven comprising means for inputting food weight, food type and desired cooking mode, for calculating a cooking time, and for applying said cooking time.

25. A microwave oven according to claim 24 in which said cooking time is calculated in accordance with initial food temperature data.

26. Cooking apparatus which includes a bar code scanner for scanning food packaging, and control means for controlling the cooking operation in dependence upon food data scanned by said bar code reader.

27. Cooking apparatus substantially as herein described with reference to any of the accompanying Figures 3-14.

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Examiner's report to the Comptroller under Section 17
(The Search report)

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Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Documents considered relevant following a search in respect of Claims :-
1-9

Categories of documents

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Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2001166 A	(MATSUSHITA) see whole document	1-3, 5, 6, 8 at least
X	US 5180896 A	(UNIVERSITY OF FLORIDA) see whole document	1-3, 5, 6, 8 at least
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